GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: August 13, 1974

Project Title: Concentration of Muscovite Fines

Project No.: A-1661

Project Director: Mr. Max F. Munoz

Sponsor: Canex Placer Limited; Vancouver, 5, B. C., Canada

Effective 7/31/74 Estimated to run until 9/30/74

Type Agreement: ~~Standard Industrial Researeh~~ Amount: $ 4,460

Reports Required: Monthly Letter Reports Final Technical Report

Sponsor Contact Person (s):

Dr. A. D. Drummond
Assistant Exploration Manager
Western Canada
Canex Placer Limited
Exploration Division
700 Burrard Building
Vancouver, 5, B. C., Canada

Assigned to Technology Applications Group Division

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 2/8/77

Project Title: Concentration of Muscovite Fines

Project No: A-1661

Project Director: Mr. M. F. Munoz

Sponsor: Canex Placer Limited, Vancouver, 5, B.C. Canada

Effective Termination Date: 10/15/75

Clearance of Accounting Charges: _____

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Assigned to: Productivity and Technology Applications (School/Laboratory)

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File: A-1661

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

September 25, 1974

Canex Placer Limited
Exploration Division
700 Burrard Building
Vancouver 5, B. C., Canada

Attention: Dr. A. D. Drummond
Assistant Exploration Manager

Subject: Monthly Progress Report, Project A-1661, "Concentration of Muscovite Fines," for Period August 15, 1974 through September 15, 1974

Dear Dr. Drummond:

The work accomplished during the above period consisted on the following:

1. Preparation of representative samples from the muscovite feed.
2. Particle size distribution analyses.

Mineral analyses on each particle size down to five microns will be started later this week.

Very truly yours,

M. F. Muñoz
Senior Research Engineer

MFM/edh

cc: Dr. J. A. Knight, Jr.
Mr. H. G. Dean, Jr.

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

Canex Placer Limited
Exploration Division
700 Burrard Building
Vancouver 5, B. C., Canada

Attention: Dr. A. D. Drummond
Assistant Exploration Manager

Subject: Final Report, Project A-1661, "Concentration of Muscovite Fines, Phase I -- Characterization of Crude Tailing Feed"

Dear Dr. Drummond:

I am enclosing the final report of the above referenced project.

Under different cover I am also sending samples of each of the fractions below 325 mesh obtained from the crude tailings, for your observation.

It has been a pleasure working with you and I look forward to continue the work of Phase II and III of this project.

With kind regards,

M. F. Muñoz
Senior Research Engineer

MFM/edh

Enclosure (as stated)

CONCENTRATION OF MUSCOVITE FINES

Phase I -- Characterization of Crude Tailing Feed

Prepared by

M. F. Munoz

WASTE UTILIZATION LABORATORY

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY

Final Report

Phase I

Project A-1661

January 1975

I. Introduction and Specific Objectives

Sericite occurs as a constituent of the porphyry copper ore which the sponsor processes. Quartz, chlorite and feldspar are also present, and the concentration of any one of these minerals from the waste tailings presents serious problems, since all the minerals appear throughout the particle range, and since they all show similar specific gravities. The fineness of the mineral grains makes dry magnetic separation and/or high tension separation unsuitable, and the similarity of specific gravity values make decantation difficult. Recent advances in fine minerals beneficiation make possible the separation of certain mineral species at the micron range, and it is expected that the use of these techniques will yield the desired degree of concentration of sericite.

The purpose of this study has been to characterize the tailing material and to obtain information about the liberation size of the sericite and distribution of the mineral species throughout the particle size range. The results presented herein will serve as a basis for the beneficiation feasibility study.

II. Experimental Procedure

The procedure followed in the characterization of the sample consisted of size analysis followed by a detailed mineralogical analysis of the size fractions obtained.

A. Size Determination

Screen analysis were performed in triplicate on the crude sample. The -325 portion was washed through the screen and this material allowed to dry to obtain its weight. After weighing, this sample was re-suspended in water, and through control of temperature and time, sized samples were obtained by settling. The sized

fractions were the normal Tyler Screen series plus the 44 x 20μ, 20 x 10μ, 10 x 5μ and -2μ fractions which were obtained by the settling procedure. Results of these determinations are given in Table I.

B. Specific Gravity of the Crude Sample

Since the settling determinations required the measurement of the specific gravity of the crude sample, two picnometric determinations were performed, following ASTM Standard Method of Test C-135-47, "True Specific Gravity of Refractory Materials." The result is given in Table I.

C. X-Ray Diffraction Analyses of Size Fractions

A semi-quantitative technique, involving x-ray diffraction peak intensities, was used to determine the approximate percent distribution of the constituents in sized fractions from the tailings. Preliminary testing disclosed that weathering products such as montmorillonite or kaolinite were present in a negligible amount. All samples were prepared for x-ray diffraction scan as powder press samples; the mineral composition was determined from peak intensities on the resulting diffractogram. Intensity values of respective peaks were multiplied by a weight factor based on experiments of known materials (standard) designed to duplicate the prototype. The peak and weight factor used to determine the various minerals are as follows:

1. Quartz was computed as three times the 4.26 Å peak intensity.
2. Feldspar was computed as one times the 3.21 Å peak intensity.
3. Sericite (mica)was computed as two times the 10 Å peak intensity.
4. Chlorite was computed as two times the 14.5 Å peak intensity after it was determined that montomorillonite and vermiculite were not present. This value proved satisfactory on prepared

TABLE I

PARTICLE SIZE ANALYSIS OF CRUDE FEED

-- Specific Gravity of Crude Feed: 2.56 --

	Feed	+35	35 x 48	48 x 65	65 x 100	100 x 150	150 x 200	200 x 325	44 x 20μ	20 x 10μ	10 x 5μ	5 x 2μ	-2μ
Percent Weight	100.0	13.3	11.5	9.8	10.8	8.3	8.0	8.3	16.5	7.8	2.5	2.3	.9
Cummulative Percent Weight	100.0	13.3	24.8	34.6	45.4	53.7	61.7	70.0	86.5	94.3	96.8	99.1	100.0

standard samples used in the evaluation.

The results for the various size fractions are presented in Table II.

D. Petrographic Examination of Feed Sample Fractions

The +40, 40 x 60, 60 x 100, 100 x 200, and -200 mesh size fractions were examined by means of megascopic and petrographic microscopes. More than 300 grains of each mesh fraction were analyzed, and the results obtained are shown in Table III.

III. Discussion of Results

The results shown in Tables II and III indicate that the sericite occurs as discrete particles below 200 mesh, and that the particle size range 20 x 5μ is especially rich in sericite.

It should be pointed out that the apparent disparity between the feldspar and mica values of the x-ray diffraction results (Table II) and the petrographic analysis results (Table III) is due to difference of the basis of percentage. The x-ray diffraction results are based on percent weight of the standard mixtures used, while the petrographic results are point-count percentages.

Since the crude feed is a waste product of a copper beneficiation operation, the results obtained in this study point out the desirability of classifying the crude feed (tailings) and using either the -200 or the -325 mesh fraction as the feed for the sericite beneficiation operation. Assuming that the amount of -325 mesh (30 percent of the total amount of tailings) provides sufficient feed material for the beneficiation step, and in turn, yields the expected amount of sericite, the advantages of using the -325 mesh fraction as feed for the sericite concentration are:

TABLE II

X-RAY DIFFRACTION ANALYSES OF SIZED SAMPLES

-- Results are Expressed as Weight Percents --

	Feed	+35	35 x 48	48 x 65	65 x 100	100 x 150	150 x 200	200 x 325	44 x 20μ	20 x 10μ	10 x 5μ	5 x 2μ	-2μ
Quartz	25	42	33	38	33	33	51	60	55	12	20	18	13
Feldspar	20	23	27	20	19	35	15	10	21	10	20	20	13
Sericite (Mica)	37	25	30	35	29	20	25	20	18	67	50	50	61
Chlorite	18	10	10	7	19	12	9	10	6	11	10	12	13
	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE III

PETROGRAPHIC EXAMINATION OF CRUDE FEED FRACTIONS

Size Fraction, Tyler Mesh	Observations
+35	Trace amount of muscovite. All of the sericite occurs as alteration products on surfaces of feldspar which comprise about half of this fraction. No discrete sericite particles.
35 x 60	About one percent muscovite observed. No discrete sericite particles, but feldspars contain "bundles" of sericite alteration. The alteration of the feldspar ranges from very minor to nearly total particle. Feldspar approximately 60 percent of fraction.
60 x 100	About three percent muscovite. No discrete sericite particles, but about 25 percent of fraction are "bundles" of sericite. About 10 percent is feldspar with appreciable sericite alteration.
100 x 200	No discrete sericite particles. About 30 percent homogeneous "bundles" of sericite. Some sericite on feldspar surfaces.
-200	Sericite comprises about 30 percent of the material, and occurs as discrete particles. This is the liberation size of sericite.

1. Absence of grinding. Desliming at 325 mesh will produce a fine material suitable as filler for industrial uses.
2. Since the liberation size of sericite occurs at 200 mesh any beneficiation procedure used in the finer than 325 mesh would concentrate discrete particles of sericite.

The -325 mesh fraction could then be beneficiated using a number of available techniques, common to the kaolin industry. The techniques that are suggested to be tried are:

1. Differential flocculation of the sericite or of the mineral impurities.
2. Flotation of sericite. Froth flotation of fine particles could be performed by emulsion flotation.
3. High intensity wet magnetic separation of chlorite.
4. Chemical leaching of quartz and feldspar. This is feasible due to the fine size of these two minerals.

Now that the impurity suite distribution over the particle size and the liberation size of the sericite is known, one or several of these techniques may be used to produce a satisfactory sericite concentrate that will meet the necessary industrial specifications.

IV. Summary and Conclusions

The purpose of this study was to characterize the flotation tailings of a copper concentration process, which contains sericite, a mineral valuable as a

filler and/or pigment. A study was made to determine the nature of the mineral impurities as well as the distribution of these impurities.

The results of this study conclusively show that in the sample submitted the sericite occurs as:

1. Free particles below 200 mesh (74 microns), and
2. The maximum concentration of sericite throughout the particle range occurs between 20 and 5 microns.

These results favor entering the second phase of the research program as initially proposed: research of concentration methods for the sericite. Froth flotation, differential flocculation, high intensity magnetic separation and chemical leaching are the techniques proposed.

V. Recommendations for Future Work

Implementation of Phase II of the original proposal is recommended to determine the feasibility of the beneficiation of the sericite from the other minerals.

The results from Phase I should be used to establish the conditioning and preparatory experimentation prior to beneficiation.

The work under Phase II should include investigation of the four beneficiation techniques outlined before, i.e., froth flotation of sericite, differential flocculation of sericite or of gangue, separation of chlorite through high intensity wet magnetic separation or dissolution of quartz and feldspar through leaching. The results obtained should point out clearly which beneficiation techniques (or combination of techniques) are feasible.

A program which will involve the Phase II "Feasibility Beneficiation Study," could be probably completed in six months plus one month for the preparation of the report. It is estimated that the work outlined above in Phase II could be

completed at a cost of $5,200 for Direct Salaries and Wages, $400 for Materials and Supplies and $5,200 for Indirect Expenses, with a total for six months of $10,800 on a cost-reimbursable contractual basis.

A-1661

CONCENTRATION OF MUSCOVITE FINES

Phase II -- Feasibility Beneficiation Studies

Prepared by

M. F. Munoz
MINERAL BENEFICIATION RESEARCH
WASTE UTILIZATION LABORATORY
ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY

Final Report

Phase II

Project A-1661

April, 1976

INTRODUCTION

Sericite occurs, along with quartz, feldspar and chlorite, in the porphyry copper ore which the sponsor processes.

Under Proj.A-1661,phase I, this ore was characterized and found that the liberation size of sericite occurred at 200 mesh, and that several size fractions below 325 mesh (44 microns) were naturally rich in sericite.

Work done in phase II, reported herein, describes the feasibility beneficiation studies performed on another sample of the copper tailings of the sponsor. The purpose of this work has been to determine if it is feasible to concentrate sericite through froth flotation, high intensity wet magnetic separation and differential dissolution techniques. The information presented herein will serve as a basis for the eventual processing of this mineral.

EXPERIMENTAL WORK

1. Sample Preparation and Size Analysis of Crude.

The sample received was air dried and mixed by the ring and cone method. A representative sub-sample was taken and divided into two samples: one for laboratory reference and the other for particle size analysis. The results of the particle size analysis determination are shown together with the results of the size analysis performed on Phase I of this study in Table I.

The bulk of the sample was screened at 325 mesh. The oversize was dried and stored and the undersize slurried with water. The -325 mesh portion was deslimed at 2 microns. The slimes (-2 microns) were flocculated, dried and stored. The 44 X 2 micron fraction was spread out, air dried, and bagged to be used as the feed in the experimental determinations.

2. Experimental Scope

The feed material (44 X 2) was used in the beneficiation investigations. Wet magnetic separation of chlorite was studied, as well as dissolution of quartz and/or feldspar through leaching. Froth flotation was also investigated as a separation technique to concentrate sericite.

The results obtained were assessed by determining the percent brightness of the beneficiated products with a B & L Spectrometer equipped with a brightness meter. The meter was calibrated with an MgO standard. Further, the beneficiated products (except the flotation products) were analyzed by X-ray diffraction.

A. High Intensity Wet Magnetic Separation

The investigations were carried out by slurrying 50 gm. batches of the feed (44 X 2 microns) with deionized water in a Hamilton Beach blender. The

solids were added gradually to 150 ml. of water, and mixing was continued for one minute after addition of solids. About 10 ml. of water were used in addition to transfering the slurry to the feeding vessel to the high intensity magnetic separator. The magnetic separator is capable of subjecting the slurry to fields in excess of 25,000 gauss at full power.

The procedure followed consisted of turning the field on, then opening the valve of the feeding vessel and allowing the slurry to enter the removable container located in the place of maximum field gradient of the separator for a measured period of time. At the end of that time, the petcock at the bottom of the container was opened and the diamagnetic and weakly paramagnetic materials("non-magnetics") allowed to drain. The petcock was then closed, the field turned off, and the container passed through a demagnetizing coil five times. Finally the paramagnetic minerals ("magnetics") were collected into a beaker by washing.

The total operation described above was called "a pass," and the effect of the number of passes at one minute and three minutes retention times was observed. Further, the effect of retention time was determined by keeping the solids concentration of the slurry and the number of passes constant. Retention times of 1, 3, 5, 8, and 10 minutes were used. The results are shown in Table II.

The effect of the solids concentration on the concentration of sericite was investigated next. Slurries with dry solids concentrations of 10, 15, 20, 30, 35, and 40 percent were passed through the magnetic separator at 5 minutes per pass, 3 passes per solid concentration test. Results are shown in Table III. Dispersion of the particles was believed an important consideration, so two known dispersants were used: Tetrasodium pyrophosphate (TSPP) and NaOH.

Results of the magnetic separation on slurries containing 25% dry solids at 3 passes are shown in Table IV. The range of TSPP used was 0.1 to 1.0 percent on the basis of dry solids. Table V shows results of the magnetic separation using NaOH in concentrations of 0.1 to 1.0 percent on the basis of dry solids. Since flocculation was observed at such strength, the series was repeated using NaOH diluted tenfold. Results are shown in Table VI.

One final series was run by repassing the magnetic concentrate ("scavenging" the sericite). The tests were run at 25% solids, 3 passes per test for the nonmagnetic fraction (as usual) and 3 minutes of retention time per pass.

Samples S-1 1st. Mag, 2nd and 3d Mag, and Non-Mag in this series represent the magnetic concentrate, the combined magnetics of passes 2 and 3, and the non-magnetic product, respectively of test S-1.

The samples of Test S-2 are the 1st. magnetic concentrate cleaned twice. The non-magnetics scavenged from the magnetic concentrate first pass, the combined second and third magnetic concentrates passed through the separator together, the non-magnetics scavenged from the 2nd. and 3rd. magnetic concentrates, and finally the non-magnetic concentrate.

Test S-3 was a repeat of test S-1 with the addition of 0.1% T.S.P.P. Test S-4 was similar to test S-2, except that 0.1% T.S.P.P. was added as a dispersant.

Test S-5 consisted of passing the slurry through the separator with no retention attemped to simulate a production-type magnetic separator.

Results are shown in Table VII.

B. Differential Dissolution Determinations

The leaching tests were performed using three agents: hydrochloric acid, hydrofluoric acid, and sodium hydroxide.

B - 1 Hydrochloric Acid Leaching Tests

50 gms. of dry 44 X 2 micron feed were placed in a 250 ml. beaker. To these beakers 150 ml. of various concentrations of HCl solutions were added

for dissolution. The concentrations of HCl chosen were 1, 3, 6, 9 and 12 molar which correspond to 3.1, 9.3, 18.6, 27.9, and 37.2 percent HCl, respectively.

During the leaching the slurry was stirred every 3 minutes. Following completion of the leaching period, the beaker's contents were stirred vigorously and poured into a 1000 ml. beaker containing 500 ml. of deionized water. After rinsing the 250 ml. beakers and adding the rinsing water to the 1000 ml. beaker, the diluted slurry was filtered through a Whatman No. 40 ashless filter paper. The solids remaining in the paper were washed twice with deionized water. All the filtrates were combined and dried in the oven. The leached solids were also dried and reserved for brightness (reflectance) measurements and X-ray mineralogical analyses after weighing.

The results obtained in the HCl series in which the concentration of acid, the leaching time, the concentration of solids in the slurry, and the leaching temperature were varied, are shown in Table VIII.

B - 2 Hydrofluoric Acid Leaching Tests

The procedure followed was very similar to the method used in the HCl leaching tests, with the exception that polyethylene beakers were used to avoid silica contamination. Results are shown in Table IX.

B - 3 Sodium Hydroxide Leaching Tests

Essentially the same procedure was followed in the NaOH leaching tests. Since the dissolution was carried out in most cases with a boiling solution, the slurry was contained in stainless steel beakers with an inverted plastic funnel on top to serve as a reflux trap. Some of the information concerning dissolution of quartz in clays with NaOH is available in the literature.[1,2] Results of the tests are shown in Table X.

C. Flotation Determination

Layer silicates are easily floated from quartz and feldspar with amines in acid circuits.[3,4] A typical procedure used to float the layer silicates from quartz and feldspar was the following:

1. Weigh 200 gm. charge of 44 X 2 microns feed.
2. Measure and mix reagents:
   a. Armac T Acetate
   b. Yarmor Pine Oil
   c. Kerosene (Sp. Gr. 0.820)
3. Place charge in flotation cell and add water to make up slurry with approximately 40% solids.
4. Adjust pH to 3.0 with H_2SO_4.
5. Condition slurry 0.5 minutes at 1100 RPM.
6. Dilute to approximately 25% solids.
7. Float for 3-10 minutes.
8. Collect concentrate (froth product) and tails; dry and weigh.

Flotation tests 1 to 16 were performed on 44 X 2 microns feed. Since there was a limited amount of this feed, flotation tests 17 to 26 were performed on 100 X 325 mesh feed. Test 27 was carried out using a fast charge of carefully sized 44 X 20 microns feed. Data obtained on the flotation tests are shown in Table XI. X-Ray diffraction analyses of the products of tests 19, 27 and 28 shown in Table XII.

D. Brightness (Reflectance) Measurements

The brightness of the samples tested was measured by a standard kaolin brightness procedure.[5] Since the samples have to contain less than 1.5% moisture for the test, the samples were dried overnight at 104°C. All samples were screened first through a 200 mesh screen and then packed and prepared at a constant packing pressure. The brightness measurement were made on a Bausch-Lomb Spectronic 20 equipped with the Color Analyzer Reflectance Attachment, at 458 millimicrons. A MgO standard was used as 100.0 throughout the work. Three readings were taken and the average computed.

E. X-Ray Mineralogical Semi-Quantitative Analysis

The procedure followed was identical with the analyses performed in Phase I of this work. "The intensity values of the respective peaks were multiplied by a weight factor based on experiments with known materials designed to duplicate the prototype. The peak and weight factor used to determine the various minerals are as follows:

1. Quartz was conputed as three times the 4.26 A^{o} intensity.
2. Feldspar was computed as one times the 3.21 A^{o} peak intensity.
3. Sericite was computed as two times the 10 A^{o} peak.
4. Chlorite was computed as two times the 14.5 A^{o} peak intensity after it was determined that montnorillonite and vermiculite were not present. This value proved satisfactory on prepared standard samples used in the evaluation." [6]

TABLE I

SIZE AND MINERAL CONTENT OF FEEDS

Size	Phase I Feed		New Feed	
	% Wt.	Cum % Wt.	% Wt.	Cum % Wt.
+100 Tyler Mesh	45.4	45.4	43.3	43.3
100 X 325 Tyler Mesh	24.6	70.0	20.8	64.1
44 X 2 Microns	29.1	99.1	35.0	99.1
- 2 Microns	0.9	100.0	0.9	100.0
	100.0		100.0	

Calculated Mineral Content of 44 X 2 Micron Fraction	% Weight
Chlorite	8.3
Sericite	36.4
Quartz	37.5
Feldspar	17.9

TABLE II

EFFECT OF RETENTION TIME IN MAGNETIC SEPARATOR ON CONCENTRATION OF SERICITE

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Dis-persant used	% Dis-persant	Wt. Sample of Total	% Re-flectan-ce	% Chlorite	% Sericite	% Quartz	% Feldspar
RT-1 1st Mag	25	3	none	-	23.4	49.0	41	45	5	9
RT-1 2nd Mag	25	3	none	-	18.8	*	32	39	19	10
RT-1 3rd Mag	25	3	none	-	13.1	*	19	43	27	11
RT-1 Non-Mag	25	3	none	-	44.7	58.2	7	50	24	19
RT-2 1st Mag	25	5	none	-	23.3	47.7	40	36	17	7
RT-2 2nd Mag	25	5	none	-	17.4	*	34	34	19	13
RT-2 3rd Mag	25	5	none	-	12.2	*	27	42	21	10
RT-2 Non-Mag	25	5	none	-	47.0	59.2	11	48	28	13
RT-3 1st Mag	25	8	none	-	23.3	46.9	39	34	15	12
RT-3 2nd Mag	25	8	none	-	16.5	*	38	39	13	10
RT-3 3rd Mag	25	8	none	-	12.4	*	24	40	26	10
RT-3 Non-Mag	25	8	none	-	47.8	57.9	13	47	28	12
RT-4 1st Mag	25	10	none	-	22.1	47.0	43	37	13	7
RT-4 2nd Mag	25	10	none	-	15.9	*	28	39	22	11
RT-4 3rd Mag	25	10	none	-	12.3	*	29	40	20	11
RT-4 Non-Mag	25	10	none	-	49.7	57.8	9	56	20	15
RT-5 1st Mag	25	1	none	-	19.7	47.7	48	40	5	7
RT-5 2nd Mag	25	1	none	-	16.9	*	38	33	21	8
RT-5 3rd Mag	25	1	none	-	11.6	*	34	41	17	8
RT-5 Non-Mag	25	1	none	-	51.8	57.9	13	56	16	15
Calculated Head Feed					100.00		24	45	19	12

* Not Determined

TABLE III

EFFECT OF CONCENTRATION OF SOLIDS IN THE SLURRY
ON THE CONCENTRATION OF SERICITE THROUGH MAGNETIC SEPARATION

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Dispers-ant used	% Dispersant	% Wt. Sample of Total	% Reflec-tance	% Chlorite	% Sericite	% Quartz	% Feldspar
SC-1 1st Mag	10	5	none	-	40.1	50.2	40	37	13	10
SC-1 2nd Mag	10	5	none	-	24.9	*	20	43	24	13
SC-1 3rd Mag	10	5	none	-	16.7	*	11	39	37	13
SC-1 Non-Mag	10	5	none	-	18.3	*	3	45	30	22
SC-2 1st Mag	15	5	none	-	35.9	49.0	32	41	19	8
SC-2 2nd Mag	15	5	none	-	21.7	*	30	40	14	16
SC-2 3rd Mag	15	5	none	-	16.3	*	17	64	10	9
SC-2 Non-Mag	15	5	none	-	26.1	60.2	4	46	31	19
SC-3 1st Mag	20	5	none	-	30.1	49.1	37	36	17	10
SC-3 2nd Mag	20	5	none	-	19.5	*	26	41	18	15
SC-3 3rd Mag	20	5	none	-	14.8	*	18	34	34	14
SC-3 Non-Mag	20	5	none	-	35.6	60.0	9	41	32	18
SC-4 1st Mag	30	5	none	-	18.6	49.3	38	34	18	10
SC-4 2nd Mag	30	5	none	-	20.0	*	37	35	18	10
SC-4 3rd Mag	30	5	none	-	13.6	*	31	42	19	8
SC-4 Non-Mag	30	5	none	-	47.8	58.6	6	53	26	15
SC-5 1st Mag	35	5	none	-	20.1	51.0	47	31	13	9
SC-5 2nd Mag	35	5	none	-	17.5	*	40	37	14	9
SC-5 3rd Mag	35	5	none	-	13.2	*	32	35	24	9
SC-5 Non-Mag	35	5	none	-	49.2	58.2	8	50	26	16
SC-6 1st Mag	40	5	none	-	17.4	51.0	38	41	13	8
SC-6 2nd Mag	40	5	none	-	17.7	*	26	27	31	16
SC-6 3rd Mag	40	5	none	-	14.2	*	25	34	26	15
SC-6 Non-Mag	40	5	none	-	50.7	57.9	12	48	27	13
Calculated Head Feed					100.0		23	42	22	13

* Not Determined

EFFECT OF TSPP CONTENT ON THE CONCENTRATION OF SERICITE THROUGH MAGNETIC SEPARATION

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Disper-sant used	% Dispersant	% Wt. Sample of Total	% Reflec-tance	% Chlorite	% Sericite	% Quartz	% Feldspar
TS-1 1st Mag	25	3	TSPP	0.1	47.6	49.5	32	40	20	8
TS-1 2nd Mag	25	3	TSPP	0.1	26.1	*	21	45	21	13
TS-1 3rd Mag	25	3	TSPP	0.1	12.1	*	12	54	21	13
TS-1 Non-Mag	25	3	TSPP	0.1	14.2	69.5	5	39	34	22
TS-2 1st Mag	25	3	TSPP	0.25	49.7	50.1	31	38	19	12
TS-2 2nd Mag	25	3	TSPP	0.25	25.4	*	13	48	29	10
TS-2 3rd Mag	25	3	TSPP	0.25	11.0	*	11	34	39	16
TS-2 Non-Mag	25	3	TSPP	0.25	13.9	69.4	5	35	36	24
TS-3 1st Mag	25	3	TSPP	0.4	52.0	51.0	29	41	22	8
TS-3 2nd Mag	25	3	TSPP	0.4	24.7	*	14	25	42	19
TS-3 3rd Mag	25	3	TSPP	0.4	10.4	*	10	39	36	15
TS-3 Non-Mag	25	3	TSPP	0.4	12.9	72.8	4	36	35	25
TS-4 1st Mag	25	3	TSPP	0.55	53.4	51.2	31	36	22	11
TS-4 2nd Mag	25	3	TSPP	0.55	23.2	*	12	46	31	11
TS-4 3rd Mag	25	3	TSPP	0.55	10.2	*	5	43	35	17
TS-4 Non-Mag	25	3	TSPP	0.55	13.2	72.3	4	35	36	25
TS-5 1st Mag	25	3	TSPP	0.7	50.3	51.1	31	35	19	15
TS-5 2nd Mag	25	3	TSPP	0.7	24.5	*	16	48	25	11
TS-5 3rd Mag	25	3	TSPP	0.7	10.8	*	10	48	30	12
TS-5 Non-Mag	25	3	TSPP	0.7	14.4	71.9	2	46	32	20
TS-6 1st Mag	25	3	TSPP	0.85	49.1	50.5	35	38	21	6
TS-6 2nd Mag	25	3	TSPP	0.85	24.3	*	14	49	24	13
TS-6 3rd Mag	25	3	TSPP	0.85	11.6	*	5	27	44	24
TS-6 Non-Mag	25	3	TSPP	0.85	15.0	72.3	4	36	39	21
TS-7 1st Mag	25	3	TSPP	1.0	49.7	50.8	27	41	20	12
TS-7 2nd Mag	25	3	TSPP	1.0	24.0	*	15	38	32	15
TS-7 3rd Mag	25	3	TSPP	1.0	10.9	*	5	49	28	18
TS-7 Non-Mag	25	3	TSPP	1.0	15.4	71.7	4	40	34	22
Calculated Head Feed					100.0		21	40	26	13

* Not Determined

EFFECT OF SODIUM HYDROXIDE AS A DISPERSANT ON THE CONCENTRATION OF SERICITE THROUGH MAGNETIC SEPARATION

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Dis-persant used	% Disper-sant	% Wt. Sample of Total	% Re-flectance	% Chlorite	% Sericite	% Quartz	% Feldspar
N-1 1st Mag	25	3	NaOH	0.1	18.6	51.1	31	35	25	9
N-1 2nd Mag	25	3	NaOH	0.1	21.6	*	36	36	20	8
N-1 3rd Mag	25	3	NaOH	0.1	19.0	*	22	40	25	13
N-1 Non-Mag	25	3	NaOH	0.1	40.8	61.8	10	37	36	17
N-2 1st Mag	25	3	NaOH	0.25	19.4	51.2	40	40	13	7
N-2 2nd Mag	25	3	NaOH	0.25	14.8	*	38	33	15	14
N-2 3rd Mag	25	3	NaOH	0.25	13.6	*	33	44	14	9
N-2 Non-Mag	25	3	NaOH	0.25	52.2	56.1	16	47	24	13
N-3 1st Mag	25	3	NaOH	0.4	17.4	50.8	30	23	32	15
N-3 2nd Mag	25	3	NaOH	0.4	15.1	*	42	35	14	9
N-3 3rd Mag	25	3	NaOH	0.4	12.9	*	18	28	39	16
N-3 Non-Mag	25	3	NaOH	0.4	54.6	55.8	13	33	18	36
N-4 1st Mag	25	3	NaOH	0.55	17.7	50.8	33	38	18	11
N-4 2nd Mag	25	3	NaOH	0.55	13.7	*	39	33	19	9
N-4 3rd Mag	25	3	NaOH	0.55	12.1	*	32	32	29	7
N-4 Non-Mag	25	3	NaOH	0.55	56.5	55.3	14	48	25	13
N-5 1st Mag	25	3	NaOH	0.7	16.7	51.8	37	36	18	9
N-5 2nd Mag	25	3	NaOH	0.7	13.2	*	27	29	27	17
N-5 3rd Mag	25	3	NaOH	0.7	12.4	*	25	26	34	15
N-5 Non-Mag	25	3	NaOH	0.7	57.7	55.8	17	48	22	13
N-6 1st Mag	25	3	NaOH	0.85	14.0	50.0	41	41	11	7
N-6 2nd Mag	25	3	NaOH	0.85	13.8	*	37	31	22	10
N-6 3rd Mag	25	3	NaOH	0.85	12.6	*	34	42	15	7
N-6 Non Mag	25	3	NaOH	0.85	59.6	55.8	15	45	25	15
N-7 1st Mag	25	3	NaOH	1.0	15.2	50.1	41	36	15	8
N-7 2nd Mag	25	3	NaOH	1.0	13.9	*	41	44	8	7
N-7 3rd Mag	25	3	NaOH	1.0	11.7	*	38	43	12	7
N-7 Non-Mag	25	3	NaOH	1.0	59.2	55.2	17	50	23	10
Calculated Head Feed					100.0		24	40	22	14

* Not Determined

EFFECT OF LOWER CONCENTRATIONS OF NaOH AS DISPERSANT ON THE CONCENTRATION OF SERICITE THROUGH MAGNETIC SEPARATION

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Dis-persant used	% Disper-sant	% Wt. Sample of Total	% Re-flectance	% Chlorite	% Sericite	% Quartz	% Feldspar
DN-1 1st Mag	25	3	NaOH	0.1	18.4	49.9	39	28	22	11
DN-1 2nd Mag	25	3	NaOH	0.1	20.5	*	38	39	15	8
DN-1 3rd Mag	25	3	NaOH	0.1	19.6	*	17	47	28	8
DN-1 Non-Mag	25	3	NaOH	0.1	41.5	61.0	6	53	25	16
DN-2 1st Mag	25	3	NaOH	0.01	30.6	51.1	39	34	19	8
DN-2 2nd Mag	25	3	NaOH	0.01	27.4	*	28	41	17	14
DN-2 3rd Mag	25	3	NaOH	0.01	18.0	*	17	48	25	10
DN-2 Non-Mag	25	3	NaOH	0.01	24.0	66.4	7	50	27	16
DN-3 1st Mag	25	3	NaOH	0.025	30.9	49.1	42	43	10	5
DN-3 2nd Mag	25	3	NaOH	0.025	28.5	*	28	34	27	11
DN-3 3rd Mag	25	3	NaOH	0.025	18.6	*	12	25	38	25
DN-3 Non-Mag	25	3	NaOH	0.025	22.0	67.2	9	49	24	18
DN-4 1st Mag	25	3	NaOH	0.04	31.3	48.9	43	43	8	6
DN-4 2nd Mag	25	3	NaOH	0.04	28.9	*	19	33	34	14
DN-4 3rd Mag	25	3	NaOH	0.04	17.6	*	13	54	21	13
DN-4 Non-Mag	25	3	NaOH	0.04	22.2	68.2	4	54	27	15
DN-5 1st Mag	25	3	NaOH	0.055	27.5	48.2	42	41	12	5
DN-5 2nd Mag	25	3	NaOH	0.055	27.8	*	18	30	35	17
DN-5 3rd Mag	25	3	NaOH	0.055	19.2	*	13	41	32	14
DN-5 Non-Mag	25	3	NaOH	0.055	25.5	66.1	7	42	25	26
DN-6 1st Mag	25	3	NaOH	0.07	20.1	48.2	48	36	9	7
DN-6 2nd Mag	25	3	NaOH	0.07	26.7	*	25	29	28	18
DN-6 3rd Mag	25	3	NaOH	0.07	19.7	*	22	49	16	13
DN-6 Non-Mag	25	3	NaOH	0.07	33.5	64.1	5	55	23	17
DN-7 1st Mag	25	3	NaOH	0.085	19.9	47.8	47	41	6	6
DN-7 2nd Mag	25	3	NaOH	0.085	25.1	*	28	47	16	9
DN-7 3rd Mag	25	3	NaOH	0.085	20.1	*	20	37	29	14
DN-7 Non-Mag	25	3	NaOH	0.085	34.9	63.2	9	49	28	14
Calculated Head Feed					100.0		23	42	22	13

* Not Determined

TABLE VII

EFFECT OF MAGNETIC SCAVENGING OF MAGNETIC CONCENTRATES

Sample No.	% Solids in Slurry	Re-tention Time, Min.	Dis-persant used	% Dis-persant	% Wt. Sample of Total	% Reflec-tance	% Chlorite	% Sericite	% Quartz	% Feldspar
S-1 1st Mag	25	3	none	-	19.0	49.9	40	32	19	9
S-1, 2nd & 3rd Mag	25	3	none	-	30.6	51.2	36	41	12	11
S-1 Non-Mag	25	3	none	-	50.4	60.0	12	47	27	14
S-2 1st Mag, Mag	25	3	none	-	11.3	44.0	48	27	19	6
S-2, 1st Mag, Non-Mag	25	3	none	-	7.8	*	23	33	30	14
S-2, 2nd & 3rd Mag, Mag	25	3	none	-	17.5	46.5	37	28	21	14
S-2, 2nd & 3rd Mag, Non-Mag	25	3	none	-	9.1	*	18	42	27	13
S-2 Non-Mag	25	3	none	-	54.3	60.1	14	40	34	12
S-3 1st Mag	25	3	T.S.P.P.	0.1	44.9	49.9	32	38	19	11
S-3, 2nd & 3rd Mag	25	3	T.S.P.P.	0.1	41.9	56.2	20	46	18	16
S-3 Non-Mag	25	3	T.S.P.P.	0.1	13.2	70.4	10	47	28	15
S-4 1st Mag, Mag	25	3	T.S.P.P.	0.1	32.2	49.2	36	29	27	8
S-4 1st Mag, Non-Mag	25	3	T.S.P.P.	0.1	12.3	60.4	9	41	36	14
S-4, 2nd & 3rd Mag, Mag	25	3	T.S.P.P.	0.1	27.5	55.1	20	39	30	11
S-4, 2nd & 3rd Mag, Non-Mag	25	3	T.S.P.P.	0.1	13.3	66.0	8	45	30	17
S-4 Non-Mag	25	3	T.S.P.P.	0.1	14.7	71.1	7	26	45	22
S-5 Mag	25	3	T.S.P.P.	0.1	12.9	44.5	45	30	15	10
S-5 Non-Mag	25	3	T.S.P.P.	0.1	87.1	58.2	26	46	17	11
Calculated Head Feed					100.0		24	40	24	12

* Not Determined

RESULTS OF LEACHING DETERMINATIONS USING HYDROCHLORIC ACID

Effect	Sample No.	% Solids In Slurry	% HCl in Solution	Leaching Time (hrs.)	Temp. °C	CONCENTRATE % Wt. of Total	% Reflectance	% Chlorite	% Sericite	% Quartz	% Feldspar
HCl Concentration	13	25	37.2	1.0	25	95.5	62.1	19	40	31	10
	14	"	27.9	"	"	94.9	64.0	21	41	23	15
	15	"	18.6	"	"	94.7	62.5	26	50	13	11
	16	"	9.3	"	"	96.2	60.9	25	38	21	16
	17	"	3.1	"	"	96.6	60.9	24	39	22	15
	18	"	0.0	"	"	100.0	54.1	20	36	36	8
Leaching Time	46	20	18.6	2.0	92	81.7	78.4	0	40	44	16
	32	"	"	1.5	"	84.3	77.1	4	41	37	18
	33	"	"	1.0	"	85.6	74.0	0	39	38	23
	34	"	"	0.5	"	88.8	70.9	14	38	29	19
	35	"	"	0.25	"	90.8	68.8	10	30	34	26
% Solids In Slurry	43	40	18.6	2.0	92	82.1	66.5	7	49	27	17
	44	30	"	"	"	80.9	77.1	3	38	45	14
	45	25	"	"	"	81.4	79.0	1	35	42	22
	46	20	"	"	"	81.7	78.4	0	40	44	16
	47	15	"	"	"	81.9	78.3	2	36	41	21
	48	10	"	"	"	81.7	78.8	2	35	43	20
Leaching Temperature	49	20	18.6	2.0	40	94.5	65.1	23	42	21	14
	50	"	"	"	55	90.5	67.3	20	35	27	18
	51	"	"	"	70	86.4	71.0	"	38	32	19
	52	"	"	"	85	84.3	71.9	5	41	33	21
	31	"	"	"	92	82.9	78.8	*	*	*	*
	46	"	"	"	92	81.7	78.4	0	40	44	16

* Not Determined

RESULTS OF LEACHING DETERMINATIONS USING HYDROFLUORIC ACID AS LEACHING AGENT

Effect	Sample No.	% Solids In Slurry	% HF in Solution	Leaching Time (hrs.)	Temp. °C	CONCENTRATE % Wt. of Totals	% Reflectance	% Chlorite	% Sericite	% Quartz	% Feldspar
HF Concentration	24	20	24.0	17.5	25	37.4	79.9	2	47	48	3
	26	"	12.0	2.0	92	62.8	80.4	0	69	27	4
	27	"	4.8	2.0	"	88.8	81.2	1	68	21	10
	57	"	2.4	2.0	"	96.8	70.1	13	47	26	14
	58	"	1.2	2.0	"	97.0	65.0	18	38	28	16
Leaching Time	27	20	4.8	2.0	92	88.8	81.2	1	68	21	10
	28	"	"	1.0	"	91.4	76.4	10	59	20	"
	29	"	"	0.5	"	80.8	74.2	10	60	22	8
	30	"	"	0.25	"	79.8	72.9	12	52	26	10
% Solids in Slurry	59	40	4.8	2	92	99.3	58.6	17	57	16	10
	60	30	"	"	"	95.9	71.2	16	50	19	15
	61	25	"	"	"	95.9	81.4	1	69	19	11
	27	20	"	"	"	88.8	81.2	1	68	21	10
	62	15	"	"	"	89.6	80.8	0	62	26	12
	63	10	"	"	"	68.0	81.1				
Leaching Temperature	64	20	4.8	2	25	83.2	66.9	17	52	24	7
	65	"	"	"	40	83.4	70.5	15	60	17	8
	66	"	"	"	55	88.0	71.9	11	55	20	14
	67	"	"	"	70	86.0	77.5	8	58	23	11
	68	"	"	"	85	89.2	82.5	2	67	22	9
	27	"	"	"	92	88.8	81.2	1	68	21	10

RESULTS OF LEACHING DETERMINATIONS USING SODIUM HYDROXIDE AS LEACHING AGENT

Effect	Sample No.	% Solids In Slurry	% NaOH in Solution	Leaching Time (hrs.)	Temp. °C	CONCENTRATE % Wt. of Totals	% Reflectance	% Chbrite	% Sericite	% Quartz	% Feldspar
NaOH Concentration	36	20	50	2	Boiling	94.0	33.5				
	22	"	28.6	2	"	90.2	52.3	21	37	33	9
	21	"	16.7	2	"	94.8	57.2	20	43	25	12
	40	"	15.0	2	"	95.4	58.1	22	39	29	10
	20	"	7.4	1	"	98.2	52.9	25	44	19	12
	19	"	3.8	1	"	95.4	53.8	20	46	21	13
	23	"	0.0	1	"	98.2	53.3	21	44	25	10
Leaching Time	25	20	28.6	16	25	100	55.0	19	43	28	10
	22	"	28.6	2	Boiling	90.2	52.3	21	37	33	9
	40	"	15.0	15.0	"	95.4	58.1	22	39	29	10
% Solids in Slurry	37	40	15.0	2	Boiling	98.5	59.6	18	37	29	16
	38	30	"	"	"	97.2	57.7	20	43	25	12
	39	25	"	"	"	95.2	54.6	20	30	34	16
	40	20	"	"	"	95.4	58.1	22	39	29	10
	41	15	"	"	"	94.3	59.2	26	41	19	14
	42	10	"	"	"	80.6	58.0	21	45	23	11
Leaching Temperature	53	20	15.0	2	40	100	55.1	27	46	19	8
	54	"	"	"	55	98.8	60.2	22	43	22	13
	55	"	"	"	70	98.8	56.3	25	43	23	9
	56	"	"	"	85	93.6	58.2	23	34	28	15
	40	"	"	"	Boiling	95.4	58.1	22	39	29	10

TABLE XI

RESULTS OF FROTH FLOTATION DETERMINATION

Flotation Test No.	% Weight Concentrate of Total	% Reflectance (Brightness)	Feed, Size	Lbs. Reagents Per Ton of Feed
1	85.0	56.4	44 X 2 Microns	21
2	70.3	59.9	" "	33.3
3	28.9	59.0	" "	16.5
4	39.3	59.9	" "	29.0
5	40.3	56.0	" "	41.5
6	41.6	55.8	" "	54.0
7	44.7	57.9	" "	66.5
8	46.0	56.9	" "	79.0
9	42.4	52.1	" "	129.0
10	47.2	56.1	" "	79.0
11	17.1	55.1	" "	22.6
12	29.3	53.0	" "	27.0
13	19.8	48.9	" "	52.5
14	34.6	50.5	" "	78.0
15	42.6	52.7	" "	103.5
16	71.8	51.2	100 X 325 mesh	27.0
17	24.9	48.0	" "	7.5
18	18.3	47.8	" "	4.1
19	21.2	45.9	" "	3.6
20	13.9	50.1	" "	3.1
21	22.7	51.0	" "	2.6
22	15.2	48.0	" "	2.6
23	22.5	50.8	" "	2.1
24	33.7	53.0	" "	1.9
25	27.2	50.8	" "	2.7
26	34.8	53.1	" "	3.3
27	22.7	43.0	44 X 20 microns	19.3
28	47.1	45.9	200 X 325 mesh	4.4

TABLE XII

ANALYTICAL RESULTS OF SELECTED FLOTATION TESTS

EST NO.	Head Feed Size	% wt. of Total	% Reflec-tance	% Chlo-rite	% Seri-cite	% Quartz	% Felds-par
.9 Concentrate		21.0	45.9	22	37	27	14
.9 Tailing		79.0	--	9	12	58	21
alculated Head Feed test 19	100 x 325 mesh	100.0	--	12	17	51	20
alculated content of feed from Phase I	100 x 325 mesh	--	--	10	22	48	20
7 Concentrate		22.7	43.0	29	27	17	27
7 Rougher Tailing		40.5		11	0	77	12
7 Cleaner Tailing		36.8		11	8	63	18
alculated Head Feed Test 27	44 x 20 microns.	100.0	--	15	9	58	18
alculated Content of eed from Phase I	44 x 20 microns.	--	--	6	18	55	21
8 Concentrate		47.1	45.9	14	21	53	12
8 Tailing		52.9	--	0	0	92	8
alculated Head eed test 28	200 x 325 mesh	100.0		6	10	74	10
alculated content of eed from Phase I	200 x 325 mesh			10	20	60	10

DISCUSSION OF RESULTS

1. Size Distribution and Mineral Content. As it can be seen from Table I the new feed is very close to the Phase I feed in particle size. The mineralogical analysis shown in Table I is a calculated composition of the 44 by 2 micron fraction of the feed used in this work, and it is based on the mineralogical analyses of Phase I.

The calculated head feed for each determination on Tables II, III, IV, V, VI and VII is shown at the bottom of each of these Tables.

A look at these calculated head feeds reveals that the composition of the new feed is very consistent but also different from the calculated values from the phase I feed shown in Table I.

The results suggest the necessity of a good sampling program in an on-going basis over a six month period of time to determine the variation in mineral content of whatever particle size range is desired to separate and use as feed for the sericite concentration process.

2. Magnetic Separation.

Results of variation of retention time in the magnetic separator are shown in Table II. A retention time of 5 minutes was chosen for the work shown in Table III on the basis of the highest reflectance of the non-magnetic product. Although 61% of the sericite was recovered in the Non-Magnetic product of Sample RT-5, the content of chlorite was fairly high. The results obtained in these series only point out the fact that chlorite is amenable to be separated magnetically from the other minerals. However, the fairly high concentration of sericite in all the magnetic products may indicate that the sericite is physically present in aggregates with chlorite. This is inconsistent with the liberation size analyses reported on Phase I. If there are sericite-chlorite

aggregates, interlayered (like sandwiches) as the magnetic separation data suggests this may explain the discrepancy.

The sandwich structure hypothesis may also explain the lack of sensitivity shown in the variables tested. The effect of retention time in the magnetic separator seemed to be unimportant, since comparable results are reported for 1, 3 and 10 minutes of retention.

Decreasing the slurry concentration to sharpen separation and purity of the concentration is a well known technique. Table III indicates that the weight of the non-magnetics increased as the % solids increased, and that the reflectance of the non-magnetics decreased with increased solids concentration. These results can be explained on the basis of sericite and chlorite being present as both discrete and aggregated particles.

Calculations based semi quantitative x-ray analyses of the products of the determinations suggest that up to 50% of the sericite may be bound with chlorite in the particle size investigated.

Table IV shows the effect of a dispersant in the magnetic separation. Tetrasodium pyrophosphate (TSPP) is a dispersant widely used to disperse silicates, especially clays. Through the use of a dispersant sharper separations and higher recovery of the non-magnetics were expected. As is evident from the data shown in Table IV, the separation was sharpened to obtain non-magnetic products of very low chlorite content and reflectance values bordering with reflectances of commercial products. However, the weight recovery decreased greatly, especially at the point of high reflectance, and low chlorite content (Test TS-3). Contrasting this test with Test RT-1 in Table II (same test, but without dispersant) it may be seen that dispersion of the slurry yields a poorer in chlorite and sericite non-magnetic material. The use of NaOH as a

dispersant was examined, since the role of this same chemical as a leaching agent was to be investigated.

The results obtained using NaOH as a dispersant in a concentration range of 0.1 to 1.0% on the basis of dry feed weight are shown in Table V. The slurry even at the lowest NaOH concentration was observed to be flocculated. More chlorite appeared in the non-magnetic products than in tests performed with no dispersant. Therefore, the same series was run using NaOH at a tenth of the concentration used, i.e. a range of 0.01 to 0.1%. The results obtained may be seen in Table VI, and indicate that dispersion was attained at those concentrations of NaOH. The results parallel the results shown in Table IV, using TSPP, although the weight recovery of the non-magnetics is higher and the reflectance lower for the NaOH tests. It is interesting to note low content of quartz and feldspar in the 1st. magnetic concentrate of Tests DN-4, 5, 6 and 7.

Since the data obtained in the magnetic separation work showed a large concentration of sericite in the 1st. magnetic concentrate, a series of tests were made to investigate the effect of re-cleaning (scavenging) the magnetic concentrates. Table VII shows the results obtained.

Tests S-1 and S-3 are non-scavenged tests ran for control. S-2 is the scavenged non-dispersed test similar to S-1. S-4 is the scavenged test equivalent to S-3. From the data in table VII it can be seen that the non-magnetic scavenged from the 1st. Mag and the non-magnetic scavenged from the 2nd and 3d. mags show a fair concentration of sericite and relatively low quartz, feldspar and chlorite. Still, either in dispersed or in non-dispersed systems, the chlorite appears together with the sericite. Again, this may be caused by an aggregate chlorite-sericite structure.

3.Leaching Determination. Table VIII shows data obtained by leaching the new

feed with HCL. The results obtained show increased reflectance and weight recovery with increased concentration of acid. However, the highest concentration of sericite is found in test No.15,using 18.6% HCL.

Leaching times above 1 hour seemingly dissoved the chlorite present at 20% solids and 18.6% HCL.

Solids concentration in the slurry was a minor effect when kept at or below 30%. The highest value obtained in % reflectance in this series was in test No.45, at 25% solids. The temperature best suited for leaching was, not surprisingly, the highest: 92°C. Hydrochloric acid can dissolve the chlorite differentially from sericite, but quartz and feldspar are unaffected.

The results of the leaching determinations using HF are presented in Table IX. Hydrofluoric acid seems to dissolve preferentially chlorite, quartz and feldspar, while sericite seems to resist dissolution. Leached solids ("concentrates") were obtained with sericite contents in the upper 60% and reflectance percentages well into the range of commercial pigments. It should be noted that most aluminum and iron fluorides are not very soluble; and therefore the percentage weight of the solids may be lower than reported, since they may contain insoluble fluorides.

The best leaching parameters, as seen in Table IX are: 20% solids in the slurry, a minimum of 4.8% HF in solution and a minimum of 2 hours leaching time, with the temperature maintained above 85°C. Hydrofluoric acid dissolutions show great promise of producing the necessary percentage purity and reflectance to make a good inorganic pigment and/or filler.

Sodium hydroxide leaching determinations did not produce any significant dissolution of quartz even at 15 hours of boiling. Some dissolution of feldspar may

have taken place in tests 22, 25, 40, 53 and 55.

4. Flotation Determination.

The surface characteristics of the minerals present in the feed, quartz, feldspar, chlorite and sericite made easy the selection of the reagents, especially the collector.

According to plant practice, layer silicates are floated from other silicates in acid circuits with cationic reagents as collectors. This can be explained on the basis of the surface charge of quartz and feldspar at low pH: the zeta-potential of these two minerals has generally a high positive value below pH 3. The layer silicates possess two types of surface structures: the plate surfaces which maintain negative charges through most of the pH range and the edge surfaces which may be positive at low pH and negative as the OH concentration increases.

The surface properties of these minerals make the selection of an amine salt at a pH below 3 the conditions of choice, and the layer silicates can be floated off as a froth concentrate. Both pine oil and kerosene are normally used as frother and froth-modifier collector-extender respectively. Froth flotation, however, is effective down to 20 microns only, and the presence of particles finer than 20 microns makes the separation blurred and uncertain, as well as increasing the reagent consumption. Table XI shows that using the 44 X 2 microns feed, up to 129 lbs. of reagents per ton were required. It should be mentioned that in the experimental work the concentration of pine oil frother and amine salt was kept constant at a fairly low level (0.1 to 5 lb/ton) while the kerosene was varied from 0.3 to 125 lb/ton. Only at extremely high oil concentrations was the froth manageable in spite of high content of fine slimes in the slurry.

Lack of feed material made necessary the use of coarser fractions, even if they contained locked particles. Reflectance determinations of the concentrates were used to guide the flotation experiments. Since chlorite and sericite float together, the higher the concentration of sericite, the lower the percent reflectance. A look at Table XI shows that using a 100 X 325 mesh feed, the reflectance of the concentrate was reduced to 45.9% and in test 27 (with a 44 X 20 microns feed) to 43.0%. Test 28 showed a low reflectance value for the concentrate with a fair weight recovery at low reagent consumption (0.3 lb/ton amine acetate, 1.7 lb/ton pine oil, 2.4 lb/ton kerosene), although the flotation was slow.

The results of Table XII (Tests 27 and 28), show that a great deal of quartz and feldspar were rejected into the tailing, although the froth concentrate produced was not of the degree of purity required. However, since the results shown represent the analysis of two flotation tests only, and since the 44x2 feed proved untreatable by flotation, the feasibility of concentrating the layer silicates present in sizes greater than 20 microns has been demonstrated. The flotation of sericite-chlorite can be optimized to produce an essentially quartz/feldspar-free concentrate. In view of the results obtained from the magnetic separation of chlorite from the other minerals (Test TS-5, Table IV), the results of hydrochloric leaching (Test 46, Table VIII) and the results obtained through hydrofluoric leaching (Tests 26,27,61, and 62, Table IX), the production of a sericite concentrate of sufficient purity and brightness (reflectance) appears feasible.

The sericite product that may be produced will have, of necessity, to be coarser than 20 microns, since that is the size limit for conventional froth flotation. If a finer product is desired from the sericite concentrate, it will have to be milled to meet the size specifications. It should be noted, however,

that a 44 x 20 microns product with sufficient uniformity and brightness could be an acceptable filler product.

Production of a finer (minus 2 micron) grade of sericite may be possible through differential flocculation, emulsion flotation or hydrofluoric acid leaching. The first two techniques require a substantial effort in time to locate optimum conditions to yield economic products. Emulsion flotation, is a very expensive process in regards to reagents, which could be as high as 200 lbs.per ton of ore [3/]. If there is locally available a cheap source of fluorite as well as sulfuric acid, HF leaching may be an attractive alternative for the manufacturing of a higher priced, fine grade of sericite.

SUMMARY AND CONCLUSIONS

The purpose of phase II of this study, was to determine the feasibility of beneficiation of sericite from the other minerals.

The results obtained in the experimental work are as follows:

1. Production of a commercial sericite product in the 44 X 20 micron range appears to be feasible by froth flotation of sericite-chlorite from the other minerals, followed by either high-intensity wet magnetic separation of chlorite or acid leaching of the concentrate to disolve chlorite.

2. Experimental results obtained point to the presence of sericite and chlorite both as discrete particles and as aggregates.

3. Chlorite was preferentially dissolved by hydrochloric acid and also by hydrofluoric acid. Sodium hydroxide leaching resulted in very minor effects.

4. Very white products with high reflectance values were produced by hydrofluoric leaching. Although the sericite content was high, these products contained substantial amounts of quartz and feldspar.

5. Chlorite was substantially reduced in non-magnetic concentrates produced in a high intensity wet magnetic separator, using a dispersant.

6. Sericite and chlorite were concentrated by conventional flotation techniques.

RECOMMENDATIONS FOR FUTURE WORK.

It is recommended that the optimization of the froth flotation of sericite-chlorite be undertaken. Better classification of feed and more selective reagents should produce sericite-chlorite concentrates of high purity with some degree of quartz and feldspar rejection as shown in Table XII.

Separation of chlorite from sericite should also be followed. A simple leaching operation produces the necessary dissolution of chlorite, but an intensive development program is necessary to obtain process parameters. The effect of pressure in the leaching operation should be also investigated.

High-intensity magnetic separation provides an alternate route for the second step of the process, and provides contrast for an economic decision.

Finally, the concentration of sericite in the fine sizes, (finer than 2 microns) should be investigated. Hydrofluoric leaching of the mineral impurities is certain to produce an industrially attractive product.

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